Response to SDAA Audit Question

Question Number: A-19.1-25

Receipt Date: 05/22/2023

Question:

1. The SDA FSAR states that the high winds (HW) PRA uses bounding assumptions (e.g., Section 19.1.5.5). However, the analysis and data used for determining the hazard frequency for hurricanes, tornadoes, and straight winds is representative of a best-estimate evaluation for an average site. Provide FSAR markups to reflect that the HW PRA hazard frequency evaluation is a best estimate for an average site is not a bounding hazard frequency.
2. On page 19.1-70 of SDAA, the licensee states that Table 19.1-36, "External Event Frequencies" provides the frequency of EF3 through EF5 tornadoes and the associated error factor. In contrast, Table 19.1-36 shows the frequency for tornado categories F2 & above. Additionally, {{

}}[2(a),(c)]. Provide FSAR markups to reconcile the difference between Table 19.1-36 and the information on page 19.1-70 of the FSAR and to reflect any resulting changes to the HW PRA results or insights.
3. Section 19.1.5 of the SDA FSAR states that Category 3 through Category 5 hurricanes (wind speed>111 mph) are included in HW PRA. In contrast, data from INL-EXT-21-64151 for wind speeds greater than 125 mph is used to determine the hurricane LOOP frequency in the HW PRA. Because Category 4 hurricanes are defined as wind speeds from 130 to 156 mph, the INL data used is likely to represent only Category 4 and Category 5 hurricanes. If Category 3 hurricanes are included in the HW PRA, either update the hurricane frequency to include events with wind speeds < 125 mph from the INL-EXT-21-64151 and provide corresponding FSAR markups or demonstrate (e.g., using results of a sensitivity) that there is no change to the HW PRA results and insights by not incorporating hurricane events with wind speeds < 125 mph from the INL-EXT-21-64151 and provide FSAR markups to reflect that only Category 4 and 5 hurricanes are included in the HW PRA.
4. The methods used to determine the tornado and hurricane strike hazards in Section 19.1.5.5.1 of SDA FSAR could affect the results and insights from the HW PRA and should be included in FSAR Table 19.1-21, "Key Assumptions for the Probabilistic Risk Assessment." Provide FSAR markups to identify the methods used to determine the tornado and hurricane

strike hazards as key assumptions for the HW PRA or provide a docketed justification why it is not a key assumption.

5. The HW PRA assumes Seismic Category I structures will not fail in high winds events. This assumption impacts the development of and results and insights from the HW PRA. However, this assumption is not included in the in FSAR Table 19.1-21, “Key Assumptions for the Probabilistic Risk Assessment.” Provide FSAR markups to identify the assumption that Seismic Category I structures will not fail in high winds events as a key assumption for the HW PRA or provide a docketed justification why it is not a key assumption.

Response:

1. NuScale revised FSAR Section 19.1 to reflect that the high winds PRA hazard frequency is a best estimate for an average site.

2. NuScale corrected the editorial error in Section 19.1.5.5.1 of the standard design approval application to indicate that the tornado hazard frequency includes EF2 to EF5 tornadoes. NuScale also corrected the referenced editorial error in {{ }}2(a),(c). These corrections result in no changes to the tornado PRA results or insights.

3. As described in FSAR Section 19.1.5.5.1, the hurricane strike frequency is based on U.S. light water reactor (LWR) operating experience. Hurricane and high-wind events that resulted in a loss of offsite power (LOOP) during critical operation were obtained from INL/EXT-21-64151, Analysis of Loss-of-Offsite-Power Events 2020 Update.

The hurricane strike frequency considers weather-related LOOP events. Although extreme weather-related LOOP events are described as having winds > 125 mph, the weather-related LOOP events identified in Appendix A of INL/EXT-21-64151 include events with hurricane winds ≥ 125 mph (identified as extreme external events), and events with high winds < 125 mph (identified as severe external events). Therefore, the high winds PRA considers events with wind speeds < 125 mph.

In response to this audit issue, NuScale added two events to the hurricane high wind frequency. On April 29, 1996, Prairie Island Units 1 and 2 experienced a LOOP as a result of severe weather and straight-line winds. NuScale originally screened these events because the “Event Description” section of the licensee event report describes the events as a result of several isolated thunderstorms. However, other sections of the licensee event report describe the events as a result of severe weather with straight-line winds. Therefore, NuScale revised the high winds PRA to include the Prairie Island events. NuScale revised FSAR Chapter 19 to reflect the updated hurricane high wind frequency, cutset results, sensitivity results, core damage frequency, and large release frequency. This update does not impact risk insights or candidate risk-significant structures, systems, and components.

4. NuScale revised FSAR Table 19.1-21, Key Assumptions for the Probabilistic Risk Assessment, to include the following assumptions, under “High Winds PRA”:

- A tornado strike hazard is determined from methods described in NUREG/CR-4461.
- A hurricane strike hazard is determined from U.S. LWR operating experience.

5. NuScale revised FSAR Table 19.1-21 to include the following assumption, under “High Winds PRA”:

- Seismic Category I structures and equipment in Seismic Category I structures, are not susceptible to damage from high winds events.

Markups of the affected changes, as described in the response, are provided below:

design-specific sources of model uncertainty, how those uncertainties are addressed and their effects on the model. Evaluating the effect of some uncertainties on PRA results required sensitivity studies.

To provide additional insights on the LRF and component importance measures, sensitivity studies are performed. Table 19.1-22 summarizes such studies, the basis for the study, and the effect on the LRF.

Table 19.1-29 summarizes key insights from the Level 2 PRA. Severe accident challenges are evaluated using deterministic and probabilistic considerations and found not to challenge CNV integrity; Section 19.2 provides further discussion.

19.1.4.3 Level 3 Internal Events Probabilistic Risk Assessment for Operations at Power

The PRA Level 3 analysis is used to evaluate offsite consequences at a potential site. A Level 3 analysis has not been performed for US460 standard design.

19.1.5 Safety Insights from the External Events Probabilistic Risk Assessment for Operations at Power

The external event hazards that may affect the NuScale risk profile are identified based on past studies and in a manner consistent with the requirements of ASME/ANS RA-Sa-2009 (Reference 19.1-2). Once the hazards are identified for consideration, the guidance in ASME/ANS RA-Sa-2009 (Reference 19.1-2) is used to implement a progressive screening process to identify which external events could be screened from detailed evaluation and those that required a quantitative hazard evaluation. The screening criteria are presented in Table 19.1-30. The table provides preliminary and bounding screening criteria using the approach discussed in Part 6 of ASME/ANS RA-Sa-2009 (Reference 19.1-2).

Table 19.1-31 summarizes the external hazards identified for consideration in the NuScale PRA for operations at power. The table provides the screening disposition for each of the hazards.

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The screening of some hazards is based on assumptions regarding siting requirements. ~~A bounding analysis of high winds and external floods was performed and s~~Site characteristics should be compared to those assumed in the high winds and external flood~~bounding~~ analyses to ensure that the site is enveloped. The seismic hazard has been addressed by performing a seismic margin assessment (SMA). The external events that are not site-specific are internal fires and internal floods.

COL Item 19.1-7: An applicant that references the NuScale Power Plant US460 standard design will evaluate site-specific external event hazards (e.g., liquefaction, slope failure), screen those for risk-significance, and evaluate the risk associated with external hazards that are not bounded by the standard design.

19.1.5.5.1 Description of High-Wind Risk Evaluation

The high-wind events considered in this evaluation are considered extreme high winds that exceed those evaluated in the internal events PRA. The wind events considered in the high-winds PRA are:

- Tornadoes with a wind speed exceeding 110 mph. Wind speeds ≤ 110 correspond to Enhanced Fujita (EF) scale ratings EF0 and EF1 are considered to be contributors to weather-related LOOP events in the internal events PRA. Thus, EF2 through EF5 tornadoes are addressed in the high-winds risk evaluation.
- Hurricanes with a wind speed exceeding 110 mph. Hurricanes having wind speeds ≤ 110 correspond to Saffir-Simpson Hurricane Wind Scale Categories 1 and 2 are considered to be contributors to weather-related LOOP events in the internal events PRA. Thus, Category 3 through Category 5 hurricanes are addressed in the high-winds risk evaluation.

The high-wind PRA applies the methodology provided in Part 7 of ASME/ANS RA-Sa-2009 (Reference 19.1-2) with consideration of the review clarifications provided in DC/COL-ISG-028. The methodology consists of a hazard analysis, fragility evaluation, and plant response evaluation. The hazards analysis considers the occurrence frequency of high-winds events. The fragility evaluation considers the susceptibility of plant SSC to high winds and wind-generated missiles. The plant response model analyzes the plant and system response to a high-winds event and quantifies CDF and LRF. The high-winds plant response model is based on the internal events model for full power conditions and adapted to incorporate aspects of the high-wind hazard.

The event trees from the internal events PRA model are reviewed for applicability to high winds. As indicated in Table 19.1-42, only the LOOP event tree, EHVS--LOOP, is considered in the high-winds PRA because (i) systems or components whose failure would otherwise result in an initiating event are located inside protective structures like the RXB or (ii) the effects of the initiating event are bounded by the LOOP evaluation. Figure 19.1-24 and Figure 19.1-25 are the full power high-winds event trees for tornado and hurricane extreme winds, respectively. The event trees are simply a transfer to the internal events LOOP event tree.

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The initiator frequency associated with the high-winds PRA is derived from the frequency of high winds exceeding 110 mph, due to either tornadoes or hurricanes. Because a specific site is not identified for standard design, a ~~bounding~~best estimate analysis for an average U.S. site is performed to assess the high-wind occurrence frequency. The high-wind initiating event frequencies are developed from the high-wind strike frequencies. For full power operation, the initiating event frequency conservatively assumes 100 percent module availability.

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To assess the tornado frequency, the methodology provided in NUREG/CR-4461 (2007) is applied. Using the "point structure" model, the probability of the wind speed exceeding a given value at a site is dependent on the total area affected by tornadoes in the region of interest divided by the total area of the region of interest over the time period under consideration. Using the “life-line” model for a tornado striking a large structure, the probability of the wind speed exceeding a given value affecting a large structure is dependent on the size of the structure and the total length of tornado paths within the region over the time period under consideration. The total tornado strike frequency of a structure is the sum of the point structure and life-line strike probabilities. The tornado hazard frequency is based on the region of the U.S. with the highest tornado intensity, central U.S. region 1, using data from NUREG/CR- 4461. The tornado initiating event for full power operations is the overall strike frequency adjusted by the module availability factor. Table 19.1-36 provides the frequency of EF2~~3~~ through EF5 tornadoes and the associated error factor.

The methodology for estimating a hurricane strike is based on U.S. LWR operating experience. Hurricane events and undefined high-wind events that resulted in a LOOP are obtained from INL/EXT-21-64151 (Reference 19.1-10). The number of events is then divided by the sum of the reactor operating years to determine the strike frequency. The hurricane initiating event for full power operations is the overall strike frequency adjusted by the availability factor. Table 19.1-36 provides the frequency of Category 3 or greater hurricanes and the associated error factor.

The high winds fragility evaluation evaluates the susceptibility of plant SSC as a function of the wind severity. Damage to equipment from extreme high winds can occur because of pressure differentials, wind generated missiles, or direct damage due to dynamic wind loadings. The fragility of SSC is evaluated using a bounding approach based on the seismic classification of structures. Table 19.1-43 summarizes building capacity to withstand high winds, which illustrates, for example, that Seismic Category I structures have only superficial damage by tornado winds categorized as EF5. Given the structural response to high winds provided in Table 19.1-43, a review of the top events in the LOOP and Level 2 event trees is performed for susceptibility to high winds.

To assess the potential for recovering power within 24 hours (to preclude a demand for the ECCS), data from INL/EXT-21-64151 (Reference 19.1-10) are reviewed; it includes data with the probabilities of exceedance versus duration for a LOOP. Based on these data a weather-related 24-hour LOOP non-recovery probability of 2.4E-01 (with an error factor of 10) is applied to tornado and hurricane events.

An operator action that is credited in the internal events PRA, but is judged not to be possible following a high-wind event is “operator loads the BDGs.” This action is judged not to be possible because the backup diesel generator enclosures are not assumed to withstand a high-wind event.

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The results of the high-winds evaluation indicate that equipment failures after a high winds-induced LOOP are randomly occurring and independent of the initiator. ~~Using bounding assumptions~~Based on this assessment, the risk associated with a high-winds event is extremely low.

19.1.6 Safety Insights from the Probabilistic Risk Assessment for Other Modes of Operation

The risk associated with full power operations is discussed in Section 19.1.4, which addresses internal events, and Section 19.1.5, which addresses external events. This section addresses the risk associated with other modes of operation, which is assessed by the LPSD probabilistic risk assessment. The LPSD probabilistic risk assessment addresses risk associated with modes other than full power operation, including low power operation, refueling outages, hot shutdown, and flooded and unflooded maintenance shutdowns.

19.1.6.1 Description of the Low Power and Shutdown Operations Probabilistic Risk Assessment

An LPSD evolution is defined as a series of connected or related activities such as a reduction in power to a low level or plant shutdown followed by the return to full-power plant conditions. Thus, the LPSD probabilistic risk assessment addresses the risk associated with Technical Specification Mode 2 (Hot Shutdown), Mode 3 (Safe Shutdown), Mode 4 (Transition) and Mode 5 (Refueling). The LPSD probabilistic risk assessment quantitatively analyzes the risk for a nominal refueling outage. The 18-month refueling cycle corresponds to a refueling frequency of 0.67 per year, and a nominal refueling outage is projected last approximately 10 days. Refueling operations are described in Section 9.1.4 and Section 9.1.5.

The nominal refueling outage is modeled as a series of seven plant operating states (POSs) that cover each arrangement of the module between shutdown and start-up. In addition to NPM arrangement, POSs are defined based on the activity being performed and availability of systems that can cause or be used to mitigate an initiating event. Each POS is described in detail below.

POS1: Shutdown and Initial Cooling: The NPM enters POS1 when the control rods are inserted and the module becomes subcritical. Normal secondary cooling through the turbine bypass is used to reduce the temperature of the primary coolant to a level that allows the CNV to be flooded, and the CVCS functions to both borate and cleanup coolant chemistry. To prevent brittle fracture of the RPV, low temperature overpressure protection (LTOP) is enabled when the RCS temperature is below the LTOP enable temperature; for the purposes of this analysis LTOP is assumed to be enabled for the entire duration of POS1. Containment flood begins and the main steam and feedwater systems are removed from service. The NPM exits POS1 when CNV flooding is complete.

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Table 19.1-21: Key Assumptions for the Probabilistic Risk Assessment

FULL POWER, INTERNAL EVENTS
Accident Sequence
If makeup inventory is needed, operators are assumed to initially align CVCS for coolant addition through the pressurizer spray line. If the RPV water level continues decreasing and operators observe increasing core temperatures, operators are assumed to realign CVCS coolant addition through the injection line.
Success Criteria
Procedures are assumed to direct operators to preserve the key safety function to remove fuel assembly heat even in cases where they would need to breach the containment boundary (e.g., operators would open the CVCS CIVs to inject makeup following incomplete ECCS actuation).
In the absence of an effective heat removal mechanism during a nominally intact reactor coolant pressure boundary scenario (that is, DHRS fails and RSVs fail to open), the RPV is expected to develop a leak (e.g., pressurizer heater access port bolted flange), and core damage is assumed.
Systems Analysis
Equipment is assumed to be operable without HVAC to support the PRA function. The small size of the equipment together with the slower progression of events provide sufficient time for any mitigating actions that might be needed.
Valve alignment for mitigating systems is assumed to include the capability to open following a loss of support systems (e.g., loss of instrument air) and accessibility for local access.
Shared systems (e.g., CFDS, DWS), are assumed to be available to support accident mitigation.
Failures are assumed to be “as-is”; failure constitutes the lack of signal generation, transmission, or interpretation through MPS equipment to the end-device.
Human Reliability Analysis
Maintenance on multiple system trains is assumed to be performed on a staggered basis; a maintenance error in the first train is assumed to be discovered before an error in the second train could occur.
For scenarios in which operators unisolate containment to initiate injection, but fail to prevent core damage, they are assumed to restore containment isolation.
Post-initiator human actions that include use of the O-1 override are assumed to require operators open the reactor trip breakers or wait until the high pressurizer level signal is no longer present, if needed.
Operators are assumed to control CVCS flow to provide necessary inventory for cooling; makeup actions are intended to maintain pressurizer level in the normal operating band.
Data Analysis
Passive safety system reliability of the DHRS and ECCS natural circulation heat transfer mechanisms are representative of the as-built, as-operated module
Component failure rates, based on design-specific analyses, are representative of the as-built module. Examples include “fails to operate” for the ECCS hydraulic-operated valve and equipment interface module.
FULL POWER, EXTERNAL EVENTS
Internal Flooding PRA
Flooding frequencies are assumed based on generic data for turbine and auxiliary buildings, including human-induced mechanisms. This is likely conservative since the NuScale design has fewer systems (hence fewer potential sources of internal flooding).
An internal flood does not result in an RSV demand if RTS and DHRS are successful.
Internal Fire PRA
Redundant divisions of safe shutdown equipment and cabling are assumed to be appropriately separated to assure at least one safe shutdown train is available following a fire.
Fire barriers are assumed between fire compartments and provide a fire resistance rating of 3 hours.
Seismic Margin Assessment
Generic spectral acceleration capacities for general component types (e.g., valves, heat exchangers, circuit breakers) are assumed applicable to components used in the NuScale design.

Table 19.1-21: Key Assumptions for the Probabilistic Risk Assessment (Continued)

Generic fragilities are assumed applicable to components in the NuScale design. The RXB is assumed to meet the seismic margin requirements of 167% of the reference earthquake for site-specific and soil-dependent seismic hazards (e.g., sliding, overturning, slope failure [instability], liquefaction). This is a design expectation.
Seismically-induced damage to reactor internals (e.g., fuel assembly, core supports, riser structure) such that the core may not be cooled is assumed to be not credible. This is a design expectation.
High Winds PRA
Although the plant is expected to use forecasting tools, a high winds event is assumed to result in a loss of offsite power with safety system actuation on low AC voltage (i.e., RTS, DHRS, and isolation of CIVs).
A tornado strike hazard is determined from methods described in NUREG/CR-4461.
A hurricane strike hazard is determined from U.S. LWR operating experience.
Seismic Category I structures and equipment in Seismic Category I structures are not susceptible to damage from high winds events.
External Flooding PRA
An external flood that exceeds the design basis flood level is assumed to have a recurrence interval of 500 years; external flooding frequency is 2E-3/yr.
Although the plant is expected to use forecasting tools, 90 percent of external floods are assumed to include significant warning time for operators to perform a controlled shutdown, the remaining 10 percent are assumed to result in a loss of offsite power with safety system actuation on low AC voltage (i.e., RTS, DHRS, and isolation of CIVs). Controlled shutdowns are assumed to result in negligible risk, and are not evaluated. Most natural flooding occurs as a result of excessive precipitation, which is relatively slow developing.
LOW POWER and SHUTDOWN[1]
The mean probability that a dropped NPM fails to remain upright is 0.5, and uncertainty is characterized with a uniform distribution.
MULTIPLE MODULE EVALUATION
Accident timing for multiple modules is not considered; that is, multiple module failures are assumed to occur within the same 72-hour mission time as the single module event.
Operator actions for inventory makeup from the CVCS and CFDS occur sequentially rather than simultaneously.
Site-wide events are assumed to affect all modules equally.
Calculated risk metrics apply to a multiple module event, irrespective of the number of installed modules; that is, all modules are assumed to be affected because of to an initiating event.
SEVERE ACCIDENT MODELING (Level 2)
In RPV overpressure scenarios, core damage is assumed with no impact on containment~~contaminant~~ integrity.

Note 1: Key assumptions for the LPSD include key assumptions made in the Full Power PRA, as applicable.

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Table 19.1-22: Sensitivity Studies

Sensitivity Description	Factor Change in CDF	Factor Change in LRF
Full Power, Internal Events		
~~Increase~~Double the LOOP initiating event frequency	1.3	1.2
Decrease LOOP initiating event frequency by an order of magnitude	0.8	0.9
Increase steam generator tube failure initiating event frequency by more than an order of magnitude, to the generic data value	1.0	1.0
Increase secondary line break initiating event frequency by more than 2 orders of magnitude, to the generic data value	1.0	1.0
~~Increase~~Double the LODC initiating event frequency	1.0	1.0
~~Increase~~Double the CVCS LOCA initiating event frequency	1.0	1.0
Increase CVCS line break outside containment initiating event frequency by an order of magnitude	1.0	3.9
Increase failure probability of passive heat removal by an order of magnitude	1.0	1.0
Increase failure probability of ECCS low differential pressure (RRVs) by a factor of 5	1.2	1.0
Include ECCS low differential pressure opening for RVVs	0.4	0.3
Decrease probability of post-trip RSV demand by a factor of 50	0.9	1.0
Assume core damage RPV overpressure sequences also result in large release	N/A	1.0
All HEPs set to 5th percentile	0.6	0.4
All HEPs set to 95th percentile	2.8	6.4
All CCF set to 0	0.1	<0.1
All CCF set to 95th percentile	>100[1]	>100[1]
Full Power, External Events		
Credit CVCS makeup in non-RXB internal floods	0.8	1.0
~~Minimize~~Set fire PRA growth to false, which stops~~; stop~~ fires before they damage mitigating equipment	0.1	<0.01
~~Minimize~~Set fire PRA growth to true, which ensures~~; allow~~ fires ~~to~~ damage mitigating equipment	14.3	2.5
~~Increase~~Double the fraction of external floods that result in a LOOP	2.0	2.1
Include ~~ECCS~~possibility of RVV low differential pressure opening ~~for RVVs~~ in the external flood PRA	0.4	0.4
Increase probabilities of not recovering offsite power in the hurricane high winds PRA by 50%	1.5	1.5~~6~~
~~Increase~~Double the frequency of a hurricane induced LOOP	~~1.9~~2.1	2.1~~2~~
Include ~~ECCS~~possibility of RVV low differential pressure opening ~~for RVVs~~ in the hurricane high winds PRA	0.4	0.4
Low Power and Shutdown		
~~Increase~~Double the failure probability of CES in POS6	1.0	1.0
Multiple Module		
~~Reduce~~Decrease MMAFs by an order of magnitude so that NPM-equipment is less correlated	0.6	0.3~~0~~
Decrease MMPSF for module-specific HFEs by a factor of 5	0.5	<0.01

Note 1: Failures assumed to be "as-is" on loss of MPS

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Table 19.1-36: External Event Frequencies

External Event (Label)	Description	Frequency (mcyr-1)	Error Factor	Transfers to Internal Event Trees
Internal Flood-RXB (IE-INTNLFLOOD-RXB)	Internal flooding in RXB	1.9 E-2	10	TGS---TRAN--NPC
Internal Flood-outside the RXB (IE-INTNL-FLOOD-OTH)	Internal flooding outside RXB	4.9 E-3	10	TGS---TRAN--NPC
External Flooding (IE-EXTNL-FLOOD-FP)	External flood, once per 500 years	2.0 E-3	10	EHVS-LOOP
High Winds-Tornado (IE-HW--TORNADO)	Tornado EF2 & Above	2.3 E-4	10	EHVS-LOOP
High Winds-Hurricane (IE-HW--HURRICANE)	Hurricane Category 3 & Above	~~9.9 E-4~~1.7 E-3	10	EHVS-LOOP
Compartment fire	Single compartment fire	2.1 E-1[1]	26	CVCS--BREAK-IOC ECCS-ALOCA-RV1 EDAS--LODC EHVS--LOOP TGS---TRAN--NPC TGS---TRAN--SS
Fire- spurious ECCS actuation (IE-FIRE-4-ECCS-FC-170-134)	Main control room fire	2.1 E-3	32	ECCS-ALOCA-RV1 TGS---TRAN--NPC
Multi-compartment fire	Fire affecting multiple compartments	3.6 E-4[1]	10	CVCS--BREAK-IOC ECCS-ALOCA-RV1 EDAS--LODC TGS---TRAN--NPC
Seismic	Not applicable for SMA			

Notes:

[1]The internal fire frequency listed is the highest of the compartments in that group.

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Table 19.1-44: Dominant Cutsets (Hurricanes, Full Power, Single Module)

Cutset	Frequency	Contribution	Description
			CDF Cutsets
1	~~2.6~~4.4E-09	24.1	
			High Winds Hurricane Category 3 & Above Initiator
			CCF OF 2 OF 4 ECCS RVV TRIP VALVES FAIL TO OPEN
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			RCS Reactor Safety Valve Not Demanded to Open
2	~~2.6~~4.4E-09	24.1	
			High Winds Hurricane Category 3 & Above Initiator
			CCF OF 2 OF 4 ECCS RVV TRIP VALVES FAIL TO OPEN
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			PROBABILITY THAT THE RSV IS DEMANDED TO OPEN
3	~~9.8E-10~~1.7E-09	9.1	
			High Winds Hurricane Category 3 & Above Initiator
			CCF OF 2 OF 2 ECCS REACTOR VENT VALVES FAIL TO OPEN
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			RCS Reactor Safety Valve Not Demanded to Open
4	~~9.8E-10~~1.7E-09	9.1	
			High Winds Hurricane Category 3 & Above Initiator
			CCF OF 2 OF 2 ECCS REACTOR VENT VALVES FAIL TO OPEN
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			PROBABILITY THAT THE RSV IS DEMANDED TO OPEN
5	~~9.8E-10~~1.7E-09	9.1	
			High Winds Hurricane Category 3 & Above Initiator
			CCF OF 2 OF 2 ECCS REACTOR RECIRCULATION VALVES FAIL TO OPEN
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			RCS Reactor Safety Valve Not Demanded to Open
6	~~9.8E-10~~1.7E-09	9.1	
			High Winds Hurricane Category 3 & Above Initiator
			CCF OF 2 OF 2 ECCS REACTOR RECIRCULATION VALVES FAIL TO OPEN

Table 19.1-44: Dominant Cutsets (Hurricanes, Full Power, Single Module) (Continued)

Cutset	Frequency	Contribution	Description
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			PROBABILITY THAT THE RSV IS DEMANDED TO OPEN
7	~~2.4~~4.1E-10	2.3	
			High Winds Hurricane Category 3 & Above Initiator
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			CCF OF 2 OF 2 APL MODULES IN ECCS REACTOR VENT VALVES FAILS TO OPERATE
			PROBABILITY THAT THE RSV IS DEMANDED TO OPEN
8	~~2.4~~4.1E-10	2.3	
			High Winds Hurricane Category 3 & Above Initiator
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			CCF OF 2 OF 2 APL MODULES IN ECCS REACTOR VENT VALVES FAILS TO OPERATE
			RCS Reactor Safety Valve Not Demanded to Open
LRF Cutsets			
1	~~8.5E-14~~1.5E-13	~~12.2~~11.6	
			High Winds Hurricane Category 3 & Above Initiator
			CCF OF 2 OF 2 CNTS CES CONTAINMENT ISOLATION VALVES FAIL TO CLOSE
			CCF OF 2 OF 4 ECCS RVV TRIP VALVES FAIL TO OPEN
			OFFSITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			RCS Reactor Safety Valve Not Demanded to Open
2	~~8.5E-14~~1.5E-13	~~12.2~~11.6	
			High Winds Hurricane Category 3 & Above Initiator
			CCF OF 2 OF 2 CNTS CES CONTAINMENT ISOLATION VALVES FAIL TO CLOSE
			CCF OF 2 OF 4 ECCS RVV TRIP VALVES FAIL TO OPEN
			OFFSITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			PROBABILITY THAT THE RSV IS DEMANDED TO OPEN
3	~~8.5E-14~~1.5E-13	~~12.2~~11.6	
			High Winds Hurricane Category 3 & Above Initiator
			CCF OF 2 OF 2 CNTS CVCS DISCHARGE LINE CONTAINMENT ISOLATION VALVES FAIL TO CLOSE
			CCF OF 2 OF 4 ECCS RVV TRIP VALVES FAIL TO OPEN
			OFFSITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)

Table 19.1-44: Dominant Cutsets (Hurricanes, Full Power, Single Module) (Continued)

Cutset	Frequency	Contribution	Description
			RCS Reactor Safety Valve Not Demanded to Open
4	~~8.5E-14~~1.5E-13	~~12.2~~11.6	
			High Winds Hurricane Category 3 & Above Initiator
			CCF OF 2 OF 2 CNTS CVCS DISCHARGE LINE CONTAINMENT ISOLATION VALVES FAIL TO CLOSE
			CCF OF 2 OF 4 ECCS RVV TRIP VALVES FAIL TO OPEN
			OFFSITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			PROBABILITY THAT THE RSV IS DEMANDED TO OPEN
5	~~3.2~~5.5E-14	4.4~~6~~	
			High Winds Hurricane Category 3 & Above Initiator
			CCF OF 2 OF 2 CNTS CES CONTAINMENT ISOLATION VALVES FAIL TO CLOSE
			CCF OF 2 OF 2 ECCS REACTOR VENT VALVES FAIL TO OPEN
			OFFSITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			RCS Reactor Safety Valve Not Demanded to Open
6	~~3.2~~5.5E-14	4.4~~6~~	
			High Winds Hurricane Category 3 & Above Initiator
			CCF OF 2 OF 2 CNTS CES CONTAINMENT ISOLATION VALVES FAIL TO CLOSE
			CCF OF 2 OF 2 ECCS REACTOR RECIRCULATION VALVES FAIL TO OPEN
			OFFSITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			RCS Reactor Safety Valve Not Demanded to Open
7	~~3.2~~5.5E-14	4.4~~6~~	
			High Winds Hurricane Category 3 & Above Initiator
			CCF OF 2 OF 2 CNTS CES CONTAINMENT ISOLATION VALVES FAIL TO CLOSE
			CCF OF 2 OF 2 ECCS REACTOR VENT VALVES FAIL TO OPEN
			OFFSITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			PROBABILITY THAT THE RSV IS DEMANDED TO OPEN
8	~~3.2~~5.5E-14	4.4~~6~~	
			High Winds Hurricane Category 3 & Above Initiator
			CCF OF 2 OF 2 CNTS CES CONTAINMENT ISOLATION VALVES FAIL TO CLOSE
			CCF OF 2 OF 2 ECCS REACTOR RECIRCULATION VALVES FAIL TO OPEN
			OFFSITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			PROBABILITY THAT THE RSV IS DEMANDED TO OPEN

Table 19.1-44: Dominant Cutsets (Hurricanes, Full Power, Single Module) (Continued)

Cutset	Frequency	Contribution	Description
9	~~3.2~~5.5E-14	4.4~~6~~	
			High Winds Hurricane Category 3 & Above Initiator
			CCF OF 2 OF 2 CNTS CVCS DISCHARGE LINE CONTAINMENT ISOLATION VALVES FAIL TO CLOSE
			CCF OF 2 OF 2 ECCS REACTOR RECIRCULATION VALVES FAIL TO OPEN
			OFFSITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			RCS Reactor Safety Valve Not Demanded to Open
10	~~3.2~~5.5E-14	4.4~~6~~	
			High Winds Hurricane Category 3 & Above Initiator
			CCF OF 2 OF 2 CNTS CVCS DISCHARGE LINE CONTAINMENT ISOLATION VALVES FAIL TO CLOSE
			CCF OF 2 OF 2 ECCS REACTOR VENT VALVES FAIL TO OPEN
			OFFSITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			RCS Reactor Safety Valve Not Demanded to Open
11	~~3.2~~5.5E-14	4.4~~6~~	
			High Winds Hurricane Category 3 & Above Initiator
			CCF OF 2 OF 2 CNTS CVCS DISCHARGE LINE CONTAINMENT ISOLATION VALVES FAIL TO CLOSE
			CCF OF 2 OF 2 ECCS REACTOR RECIRCULATION VALVES FAIL TO OPEN
			OFFSITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			PROBABILITY THAT THE RSV IS DEMANDED TO OPEN
12	~~3.2~~5.5E-14	4.4~~6~~	
			High Winds Hurricane Category 3 & Above Initiator
			CCF OF 2 OF 2 CNTS CVCS DISCHARGE LINE CONTAINMENT ISOLATION VALVES FAIL TO CLOSE
			CCF OF 2 OF 2 ECCS REACTOR VENT VALVES FAIL TO OPEN
			OFFSITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			PROBABILITY THAT THE RSV IS DEMANDED TO OPEN

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Table 19.1-45: Dominant Cutsets (Tornadoes, Full Power, Single Module)

Cutset	Frequency	Contribution	Description
CDF Cutsets			
1	6.1E-10	24.1	
			High Winds Tornado EF2 & Above Initiator
			CCF OF 2 OF 4 ECCS RVV TRIP VALVES FAIL TO OPEN
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			RCS Reactor Safety Valve Not Demanded to Open
2	6.1E-10	24.1	
			High Winds Tornado EF2 & Above Initiator
			CCF OF 2 OF 4 ECCS RVV TRIP VALVES FAIL TO OPEN
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			PROBABILITY THAT THE RSV IS DEMANDED TO OPEN
3	2.3E-10	9.11	
			High Winds Tornado EF2 & Above Initiator
			CCF OF 2 OF 2 ECCS REACTOR VENT VALVES FAIL TO OPEN
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			RCS Reactor Safety Valve Not Demanded to Open
4	2.3E-10	9.11	
			High Winds Tornado EF2 & Above Initiator
			CCF OF 2 OF 2 ECCS REACTOR VENT VALVES FAIL TO OPEN
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			PROBABILITY THAT THE RSV IS DEMANDED TO OPEN
5	2.3E-10	9.11	
			High Winds Tornado EF2 & Above Initiator
			CCF OF 2 OF 2 ECCS REACTOR RECIRCULATION VALVES FAIL TO OPEN
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			RCS Reactor Safety Valve Not Demanded to Open
6	2.3E-10	9.11	
			High Winds Tornado EF2 & Above Initiator
			CCF OF 2 OF 2 ECCS REACTOR RECIRCULATION VALVES FAIL TO OPEN
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			PROBABILITY THAT THE RSV IS DEMANDED TO OPEN

Table 19.1-45: Dominant Cutsets (Tornadoes, Full Power, Single Module) (Continued)

Cutset	Frequency	Contribution	Description
7	5.7E-11	2.25	
			High Winds Tornado EF2 & Above Initiator
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			CCF OF 2 OF 2 APL MODULES IN ECCS REACTOR VENT VALVES FAILS TO OPERATE
			PROBABILITY THAT THE RSV IS DEMANDED TO OPEN
8	5.7E-11	2.25	
			High Winds Tornado EF2 & Above Initiator
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			CCF OF 2 OF 2 APL MODULES IN ECCS REACTOR VENT VALVES FAILS TO OPERATE
			RCS Reactor Safety Valve Not Demanded to Open
LRF Cutsets			
1	2.0E-14	13.1	
			High Winds Tornado EF2 & Above Initiator
			CCF OF 2 OF 2 CNTS CES CONTAINMENT ISOLATION VALVES FAIL TO CLOSE
			CCF OF 2 OF 4 ECCS RVV TRIP VALVES FAIL TO OPEN
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			RCS Reactor Safety Valve Not Demanded to Open
2	2.0E-14	13.1	
			High Winds Tornado EF2 & Above Initiator
			CCF OF 2 OF 2 CNTS CES CONTAINMENT ISOLATION VALVES FAIL TO CLOSE
			CCF OF 2 OF 4 ECCS RVV TRIP VALVES FAIL TO OPEN
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			PROBABILITY THAT THE RSV IS DEMANDED TO OPEN
3	2.0E-14	13.1	
			High Winds Tornado EF2 & Above Initiator
			CCF OF 2 OF 2 CNTS CVCS DISCHARGE LINE CONTAINMENT ISOLATION VALVES FAIL TO CLOSE
			CCF OF 2 OF 4 ECCS RVV TRIP VALVES FAIL TO OPEN
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			RCS Reactor Safety Valve Not Demanded to Open

Table 19.1-45: Dominant Cutsets (Tornadoes, Full Power, Single Module) (Continued)

Cutset	Frequency	Contribution	Description
4	2.0E-14	13.1	
			High Winds Tornado EF2 & Above Initiator
			CCF OF 2 OF 2 CNTS CVCS DISCHARGE LINE CONTAINMENT ISOLATION VALVES FAIL TO CLOSE
			CCF OF 2 OF 4 ECCS RVV TRIP VALVES FAIL TO OPEN
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			PROBABILITY THAT THE RSV IS DEMANDED TO OPEN
5	7.5E-15	4.9	
			High Winds Tornado EF2 & Above Initiator
			CCF OF 2 OF 2 CNTS CES CONTAINMENT ISOLATION VALVES FAIL TO CLOSE
			CCF OF 2 OF 2 ECCS REACTOR VENT VALVES FAIL TO OPEN
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			RCS Reactor Safety Valve Not Demanded to Open
6	7.5E-15	4.9	
			High Winds Tornado EF2 & Above Initiator
			CCF OF 2 OF 2 CNTS CES CONTAINMENT ISOLATION VALVES FAIL TO CLOSE
			CCF OF 2 OF 2 ECCS REACTOR RECIRCULATION VALVES FAIL TO OPEN
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			RCS Reactor Safety Valve Not Demanded to Open
7	7.5E-15	4.9	
			High Winds Tornado EF2 & Above Initiator
			CCF OF 2 OF 2 CNTS CES CONTAINMENT ISOLATION VALVES FAIL TO CLOSE
			CCF OF 2 OF 2 ECCS REACTOR VENT VALVES FAIL TO OPEN
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			PROBABILITY THAT THE RSV IS DEMANDED TO OPEN
8	7.5E-15	4.9	
			High Winds Tornado EF2 & Above Initiator
			CCF OF 2 OF 2 CNTS CES CONTAINMENT ISOLATION VALVES FAIL TO CLOSE
			CCF OF 2 OF 2 ECCS REACTOR RECIRCULATION VALVES FAIL TO OPEN
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			PROBABILITY THAT THE RSV IS DEMANDED TO OPEN

Table 19.1-45: Dominant Cutsets (Tornadoes, Full Power, Single Module) (Continued)

Cutset	Frequency	Contribution	Description
9	7.5E-15	4.9	
			High Winds Tornado EF2 & Above Initiator
			CCF OF 2 OF 2 CNTS CVCS DISCHARGE LINE CONTAINMENT ISOLATION VALVES FAIL TO CLOSE
			CCF OF 2 OF 2 ECCS REACTOR RECIRCULATION VALVES FAIL TO OPEN
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			RCS Reactor Safety Valve Not Demanded to Open
10	7.5E-15	4.9	
			High Winds Tornado EF2 & Above Initiator
			CCF OF 2 OF 2 CNTS CVCS DISCHARGE LINE CONTAINMENT ISOLATION VALVES FAIL TO CLOSE
			CCF OF 2 OF 2 ECCS REACTOR VENT VALVES FAIL TO OPEN
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			RCS Reactor Safety Valve Not Demanded to Open
11	7.5E-15	4.9	
			High Winds Tornado EF2 & Above Initiator
			CCF OF 2 OF 2 CNTS CVCS DISCHARGE LINE CONTAINMENT ISOLATION VALVES FAIL TO CLOSE
			CCF OF 2 OF 2 ECCS REACTOR RECIRCULATION VALVES FAIL TO OPEN
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			PROBABILITY THAT THE RSV IS DEMANDED TO OPEN
12	7.5E-15	4.9	
			High Winds Tornado EF2 & Above Initiator
			CCF OF 2 OF 2 CNTS CVCS DISCHARGE LINE CONTAINMENT ISOLATION VALVES FAIL TO CLOSE
			CCF OF 2 OF 2 ECCS REACTOR VENT VALVES FAIL TO OPEN
			OFF-SITE POWER NOT RESTORED WITHIN 24 HOURS (HIGH WINDS)
			PROBABILITY THAT THE RSV IS DEMANDED TO OPEN

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Table 19.1-60: Summary of Results

Full Power (per mcyr)						
Hazard	**CDF (mean values)**	**5th percentile**	**95th percentile**	**LRF (mean values)**	**5th percentile**	**95th percentile**
Internal Events	6.0E-09	2.2E-10	2.1E-08	6.6E-13	<1E-15	1.5E-12
Internal Fires	4.6E-09	9.7E-11	1.6E-08	1.3E-11	3.9E-15	3.0E-11
Internal Floods	1.6E-10	1.8E-12	5.5E-10	3.4E-14	<1E-15	2.8E-14
External Floods	9.5E-09	1.4E-10	3.5E-08	1.4E-13	5.9E-15	4.3E-12
High Winds (Tornado)	2.6E-09	2.6E-11	9.5E-09	1.~~5~~6E-13	<1E-15	4.9E-13
High Winds (Hurricane)	1.9~~1~~E-08	1.9~~1~~E-10	~~4.1~~7.0E-08	~~7.6E-13~~1.3E-12	<1E-15	~~2.4~~4.3E-12
Seismic [1] (SMA)	0.92g					
Low Power and Shutdown (per year)						
Hazard	**CDF (mean values)**	**5th percentile**	**95th percentile**	**LRF (mean values)**	**5th percentile**	**95th percentile**
Internal Events	4.0E-11	9.8E-13	1.4E-10	3.5E-12	4.2E-14	1.2E-11
Module Drop	1.8E-08	2.5E-10	6.9E-08	NA [2]	NA [2]	NA [2]
Internal Fires	negligible[5]			negligible[5]		
Internal Floods	negligible[5]			negligible[5]		
External Floods	negligible[5]			negligible[5]		
High Winds (Tornado)	negligible[5]			negligible[5]		
High Winds (Hurricane)	negligible[5]			negligible[5]		
Seismic [1] (SMA)	NA					
Multi-Module						
Hazard	**Conditional Probability of Core Damage**			**Conditional Probability of Large Release**		
Multi-Module	0.21[3]			0.03[3]		
Composite CCFP < 0.1[4]						

Notes:

1. A seismic margins assessment is performed; results are presented in terms of the HCLPF (i.e., peak ground acceleration at which there is 95% confidence that the conditional failure probability is less than 5%).
2. A module drop does not result in a large release.
3. Results are presented in terms of a bounding estimate on the conditional probability that multiple modules would experience core damage (or large release) following core damage (or large release) in a single module.
4. Composite CCFP reflects contributions from all hazards.
5. Based on qualitative evaluation.

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Figure 19.1-24: High-Winds (Tornado) Event Tree